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Abstract

Whereas women earn more than half of all university degrees and make up over half of the workforce, their enrolment in computer science and information systems academic programs and their representation in technology-related career fields remain at disturbing low levels. In recent years the percentage of female graduates from these programs in the U.S., Europe, and Australia has not risen above 20%. The demand for IT workers continues to grow, yet women fill only 19% of software development positions in the U.S. A number of studies have examined gender differences related to experience, beliefs, and attitudes regarding the IT field, and a common theme is the need to improve women's perception of the field. This paper describes a first step in investigating whether the agile approach to information system development contributes to an environment that could potentially be more welcoming to women, based on a comparison of work practices and agile principles.

Keywords: Gender, STEM, Agile, Women in IT, under-representation

1.0 Introduction

While women earn more degrees, including professional degrees, than men, the number of women graduating with degrees in information technology fields is lower today than it was in 1980 (Hiner 2015). Only 19% of computer science and information systems graduates in the U.S. in 2012 were women (U.S. Department of Education, 2013). This is representative of a trend across technology fields in the US, Europe, and Australia, and in both academic programs and the workforce. Although women make up over 57% of the US workforce (BLS 2014), only 27% of STEM (science, technology, engineering, and math) jobs are filled by women. In particular, "women remain significantly underrepresented in engineering and computing occupations, occupations that make up more than 80% of all STEM employment" (Landivar, 2013, p. 1).

The exact cause(s) of this drop in female participation in the information technology field is not well understood. Women were a large part of the first computer workforce (Misa, 2010) and their participation in the field continued to grow until the late 1980's. The number of women entering computer-related degree programs started

dropping in the mid-1980's – at exactly the same time that personal computers became common in U.S. homes. It has been hypothesized that these home computers were targeted to boys, which led girls to feel excluded from the computer field (Henn, 2014). Mixed results have been found for the impact of the fit between perceived ability and interest and technology-related education and career intentions (Le et al. 2014), and it has been suggested that there is greater variation within gender than between genders (Quesenberry & Trauth 2008). Whatever the cause, it is generally believed that this disparity is a problem – not simply a matter of inequality or lack of opportunity – but a significant economic and societal problem (Google, 2014; Kongar et al. 2009).

Demand for computer and information technology workers is projected to grow 3.9% annually through 2020, compared to slower growth rates of 2.6% for professional, scientific, and technical services and 1.3% for all industries (Csorny 2013). If over half of the population is not participating in this growth, then the potential workforce to fill these technical positions is limited. In 2008, 31% of US bachelor's degrees, and even smaller percentages in the UK, Canada, and Australia, were awarded in technology (STEM) fields (Hiner, 2015). At the same time approximately 51% of technical degrees in China and 60% of technical degrees in Japan were earned by women. (Hiner 2015). In the US, this raises fears of losing the ability to compete in an increasingly technology-dominated global economy. This gender disparity also results in an IT workforce that is dominated by one gender. It has been suggested that this lack of diversity may lead to reduced creativity (IDG, 2013) and lower quality outcomes (Liang et al. 2007). There is concern that if one gender dominates the development of the technology used in a society, this may have a negative impact on the use of this technology for the other half of society. "This is in a software/internet marketplace where women are online in equal numbers to men, directly or indirectly influence 61% of consumer electronics purchases, generate 58% of online dollars, and represent 42% of active gamers" (Judy 2012, p. 5279). It is detrimental to exclude half of the population from this field, particularly in light of the fact that "while women-owned businesses only make up 4 percent of venture-backed tech companies, those women-led companies are achieving a 35% higher-than-normal return on investment and bringing in 12% higher revenue than average" (Hiner 2015, p.2).

Many interventions have been undertaken to encourage young women to enrol in computer science and information systems programs and to take up careers in the IT field. Whereas individual institutions and organizations have reported some success, looking at the overall numbers today does not provide an encouraging picture (Bernhardt 2014; Google 2014; Trauth et al. 2009)

One solution suggested is to focus efforts not on changing women but instead on changing the field in such a way that more people in general, including more women, are interested in being involved in it (Robertson et al. 2001). A few researchers and practitioners have suggested that agile information system development approaches may be more compatible with work styles identified with women (Frieze et al. 2006; Hazzan & Dublinksy 2006; Judy 2012).

This paper reports on a pilot study of software developers' perceptions of agile methods, compared to more traditional plan-driven, waterfall methods. This is part of an on-going study into women in IT.

2.0 Background: Gender and Agile Development Approaches

People work best when they feel valued, trusted, and respected (Helgesen 1990). It has been observed that "Women avoid careers in software due to hostile environments, unsustainable pace, diminished sense of purpose" among other reasons. (Judy 2012, p. 5279). The founders of the Agile Manifesto, which outlines the philosophy underlying the many agile system development approaches, challenged the prevailing opinion that software development was an activity that should be performed in a highly planned and controlled environment with hierarchies and strict role structures. Agile approaches include self-organizing teams, a high level of communication and collaboration, and a focus on meeting the needs of the product owners or users. It has been suggested (Frieze et al. 2006; Hazzan & Dubinsky 2006) that Agile values and practices have the potential to contribute to the creation of a systems development workplace environment that is better able to attract female software developers, to provide an environment in which women perceive they can achieve professional and personal fulfilment, and thus to retain these women in the software workforce (Judy 2012).

2.1 Work Style Preferences of Women

Helgesen's (1990) study of women's leadership styles and ways of working found that, in contrast to Mintzberg's classic study of male managerial styles (1973), women are more concerned with personal growth and fulfilment and making a contribution to society than in achieving recognition based on position. Whereas the women she studied scheduled time to share information, Mintzberg's male managers described requests for information to be "intrusive". The female managers paid attention to process and relationships, rather than focusing solely on the completion of tasks where the work itself becomes a means to an end (Helgesen 1990). Whereas the men in Mintzberg's study (1973) identified their authority as coming from their place at the top of the hierarchy, the female managers described by Helgesen (1990) derived their authority from connections, influence on communications, and many sources of information.

Studies have looked at gender differences in terms of teamwork, and have found that gender differences may impact both the processes and outcome of team collaboration (IDG 2013; Liang et al. 2007). From the gender stereotype perspective, men tend to take a dominating role focused on action and women have played a more supportive role, maintaining relationships among team members (Schiller et al. 2011). Other studies have identified IT skills that are more stereotypically feminine or masculine. Communication skills, relationship skills, and teamwork skills were identified as typically feminine while integration, analysis, implementation and programming were classified as masculine (Trauth et al., 2010). Whereas it is generally assumed that women are more concerned with their ability to balance family-life with work-life, this may come from early studies of gender roles (*e.g.*, Igbaria et al., 1991). More recent research does not show a strong impact of this factor (lifestyle integration) on women's degree and career choices in the computer science and information systems field (Quesenberry & Trauth 2008).

2.2 The Agile Approach

Agile approaches (see Abrahamsson et al. 2003 for a detailed description and comparison of agile methods) grew out of disenchantment with the plan-driven

(Waterfall) methods that dominated the development environment through the 1980s. Many of the creators of these documentation-light, iterative methods cooperated to create the Agile Manifesto, a declaration of the values and principles that formed the basis of Agile approaches (Agile Alliance, 2001). The Agile Manifesto indentifies four shared values which express preference for: (1) Individuals and interactions over processes and tools; (2) Working software over comprehensive documentation; (3) Customer collaboration over contract negotiation; and (4) Responding to change over following a plan. Twelve principles (see Table 1) identify ideals of the approach and are implemented to differing degrees in different agile methods. The number of agile approaches has proliferated, and its use has spread into domains for which it was not originally intended. Agile should not be assumed to be the "silver bullet" that can solve all problems with software development. Recent research has shown, however, that the agile principles retain strong support in the development community (Williams 2012).

In the following section we will identify relevant characteristics and work behaviours identified as representative of female workers and then relate those to Agile principles.

2.3 Relationship between Female Characteristics and Agile Principles

Agile methods "are designed to capitalize on each individual and each team's unique strengths" (Cockburn & Highsmith, 2001, p. 131). Teams are recommended to be self-organizing and adaptive, rather than operating under formal hierarchical conditions with strict rules and controls. Regular and intensive communication among team members and with the customer (user) is required. From the descriptions of female work and management styles and classifications of stereotypically feminine IT skills, we can begin to understand the reasons why some researchers have suggested that Agile development appears to be more "female friendly". A number of the Agile principles are compatible with characteristics that we would expect to be preferred by female IT workers. These are presented in Table 1 below.

Principle	Practices that Reflect the Principle	Reference/source
Our highest priority is to ***satisfy the customer*** through early and continuous delivery of valuable software.	Women think of others, community	Helgesen, 1990
Welcome changing requirements, even late in development.	Focus on the process and maintaining relationships; Openness to new experiences	Helgesen, 1990 Trauth et al., 2010
Deliver working software frequently... with a preference to the shorter timescale.	Work best when feel valued	Helgesen, 1990
Business people and developers must **work together** daily throughout the project.	Relationship-building; Teamwork	Schiller et al., 2011 Trauth et al., 2010
Build projects around motivated individuals. Give them the **environment and support** they need, **and trust** them to get the job done.	Group affiliation rather than individual achievement has the highest value.	Helgesen, 1990 Schiller et al., 2011 Trauth et al., 2010
The most efficient and effective method of conveying information to and within a development team is **face-to-face conversation**.	Schedule time to share information	Helgesen, 1990 Schiller et al., 2011
Working software is the primary measure of progress.	Effect on other people; making a contribution to others is valued	Helgesen, 1990
Agile processes promote **sustainable development**.	Work-life balance; Flexible work schedule	Igbaria et al., 1991 Trauth et al., 2003
Continuous attention to technical excellence and good design enhances agility.	Focus on the process not only the results	Helgesen, 1990
Simplicity--the art of maximizing the amount of work not done--is essential.	Focus on the process not only results	Helgesen, 1990
The best architectures, requirements, and designs emerge from **self-organizing teams**.	Women derive power from connections rather than from formal position.	Helgesen, 1990
At regular intervals, the team **reflects on how to become more effective**, then tunes and adjusts its behaviour accordingly.	Focus on process not only results; Schedule time to share information; Concern for others' personal development	Helgesen, 1990

Table 1. Agile Principles (from www.agilemanifesto.org) and Female Work Characteristics.

3.0 Preliminary Survey Results

A pilot survey to obtain feedback from women and men working as developers in Agile and non-Agile environments was conducted. The respondents were asked to rate a number of statements and work environment characteristics as being more representative of an Agile approach or of a Waterfall approach (or equally associated with both approaches). The statements and characteristics were representative of the female/male dominant characteristics identified in the studies described in the previous section. (Questionnaire available from the author.)

From a set of 45 responses from individuals who had worked as developers for 1-5 years, we found that all respondents, not only the women, expressed a personal preference for Agile approaches. On a 5-point scale where 1 represented Strongly Agile, 2 Somewhat Agile, 3 Neutral, 4 Somewhat Waterfall, and 5 Strongly Waterfall, the average score on preferred development approach for women was 2 and for men was 2.44. Women were much more likely to characterize the following as related to the Agile approach: need for high levels of interaction among team members, group goals being more important than individual goals, achieving the customer (user) goals, developing relationships, and a flexible work schedule. Both men and women recognized that control and hierarchy are more closely aligned with Waterfall approaches.

These results are preliminary; a larger and more diverse sample is needed to statistically test for differences between male and female developers. However, we do see some support for the hypothesis that Agile development environments may be a better fit for female developers.

4.0 Discussion & Conclusions

This paper has presented a preliminary step at investigating whether Agile development might represent a move towards an IT workplace environment that is more attractive to women. The survey was quite limited, and data was collected from a small, convenience sample of individuals affiliated with the author's university. The majority of the respondents were originally from India, and it must be

acknowledged that cultural differences may limit the applicability of the results to the U.S. and Europe (Leingpibul et al. 2006). More research is needed to determine why countries such as India, China and Japan are not experiencing the gender disparities seen in the Europe, Australia and the U.S.

The results do suggest the possibility that Agile principles may provide an environment in which women feel that they can make a greater contribution and fulfil their own needs while also improving conditions for others. However, as we have seen in other studies, it is important to acknowledge that there is a great deal of diversity within gender, as well as overlap between genders. Therefore "organisational interventions must be flexible enough to account for the diversity and variation among women" and "move away from 'one size fits all' organisational interventions that often reflect stereotypes about women in the IT workforce." (Quesenberry & Trauth, 2010). Academic institutions that have attempted to broaden the appeal of information systems and computer science programs generally have found success (increased enrollment overall, and increased gender balance) by highlighting the non-technical aspects of IT-related careers (Frieze et al. 2006; Robertson et al. 2001). Publicising the diversity of tasks, practices, roles, and types systems and their impact on society may be a more successful path to growing and diversifying the field, and Agile is one aspect of this.

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